

Big Data Analysis Based Private College Teaching Cost Problem Detection and Improvement

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Abstract—In the background of college entrance student amount declining in China, it has significant realistic meaning to enhance the comprehensive utilization of private college education resources, to control teaching cost and improve economic performance. This paper put forwards the definitions of big data based teaching cost analysis indexes, based on which a case study of school departments teaching cost problem detection and improvement is elaborated. It starts with collecting and organizing the original data from the teaching procedures. The factors of possibly affecting the teaching cost problem are decomposed. The analysis result is visualized, so that the decision support of improvement solutions of teaching management strategy can be easily provided to school departments.

Keywords—private college; big data; teaching cost

I. INTRODUCTION

With the acceleration of the process of aging in China, the tendency of the shrinking of college students is becoming more and more obvious [1]. Private colleges and universities which rely on tuition fees will face the competition and challenges of survival and development for a long time in the future. In China, most of private universities are teaching-type universities. The balance between teaching cost and teaching quality is the key problem in the teaching management decision of private colleges. At present, the teaching and administrative staff of private colleges and universities are making decisions based on their intuitionistic experience and fuzzy estimation, and they urgently need the methods and tools of scientific decision - making support for teaching management that can be analyzed quantitatively. There is also a lack of early-warning, diagnostic and control mechanisms for the cost of teaching across all faculties.

On the other hand, the majority of colleges and universities in China have achieved the full extent of teaching management information, the basic use of information systems to implement teaching management and teaching operation of the deployment of resources [2]. In the process of university information, teaching management information system produced and stored a large amount of teaching "big data", and can be based on the computer Internet transmission. Although the data management and paperless office system have been established, it has laid the necessary foundation for the introduction and application of

large data system. However, most universities in China have not got the effective information from the collected data to optimize the education and teaching management service functions.

In this context, the author, as the head of the teaching management of the college, uses the theories and techniques of large-scale data analysis of foreign universities to organize the diagnosis of the teaching cost of the college and formulate the optimization strategy of teaching management in the future.

II. SITUATION ANALYSIS

In recent years, Chinese educational theory workers have paid more and more attention to input-output research and teaching cost and benefit analysis of university teaching based on large data analysis. However, in the allocation of educational resources within the university, accounting unit of the teaching effectiveness of research is not much [3].

In China, the relevant theoretical research on the cost-effectiveness of teaching is representative of the following: In Guangxi Institute of Technology, Feng Kong and other analysis of the daily running costs and benefits of teaching the impact of factors, put forward the evaluation of the department of the daily running costs and benefits of ideas [3]. Jiangang Chen of Nanjing Xiaozhuang College analyzed the impact of their "teaching cost" and "specialty setting" on the economic benefit of running school [4]. Harbin University of Commerce Yushuang Chen and others used the Analytic Hierarchy Process AHP to analyze and compare the cost structure of each level of colleges and universities, which found that China's colleges and universities in the cost of the existing problems and give relevant policy recommendations and comments to control compensation [5]. Yan Zhou, a student of Jiangxi Normal University, chose a new teaching management system - credit system as the starting point, through the analysis of cases, the optimization of teaching resources in the university to study the problem [6]. Nanjing University of Posts and Telecommunications Jun Lin and others from the perspective of enhancing the efficiency of resource allocation of disciplines, analysis of the current internal resources allocation of colleges and universities in the status quo and existing problems, optimization of resource allocation model proposed main strategy [7].

In China there are some colleges and universities on teaching cost-effectiveness and teaching resource allocation conducted a case study and empirical research, of which there are two typical cases are as follows:

- Shandong University of Technology [8] the reform of physical education teaching practice research, the use of literature and mathematical models and other methods of sports resources in colleges and universities to analyze and derive, and in the reform practice has been verified in order to obtain the best resource utilization.
- Chengdu University of Technology [9] through the construction of disciplines by personnel training organization platform, the use of modern information technology to build uninterrupted resource sharing platform, take "to time for space, to advantage for resources" and other measures, with limited resources to ensure the implementation of the credit system.

III. TEACHING COST ANALYSIS INDEX

Through the large data analysis of teaching cost, first of all to set up teaching cost analysis indicators. However, the concept of "teaching cost" in the broad sense should include infrastructure, logistics, teachers and teaching software and hardware, and so all the expenditure. As the infrastructure, logistics and other hardware and software investment is a school-wide auxiliary costs, and the Department of conventional teaching management activities directly related to small, so the cost of teaching is a narrow concept, that is mainly concerned about the teachers and curriculum-related investment. The author introduces the calculation index of Student Study over-load which is taken by Canadian universities as the basis. These indicators are also mainly teachers and curriculum-related analytical indicators.

A. Full-Course Equivalent (FCE) [10]

FCE, Full-Course Equivalent. The number of students in a department under a 6-credit system.

$$FCE = \sum FCE'$$

where FCE' refers to the number of students in one course under a 6-credit system.

$$FCE' = c/6 \times s$$

where C refers to the Course Credits.

B. Full Time Equivalent (FTE) [11]

FTE, Full Time Equivalent. FTE is not just referring to full-time majors students at the School of Management, as well as minor and dual-degree students in other faculties of the School of Management. However, the number of these minor and dual-degree students will need to be converted into full-time students in proportion to the elective course credits and the total credits of full-time majors.

$$FTE = \sum FTE'$$

where FTE' refers to the number of Full-Course Equivalent students in a department.

$$FTE' = x + y \cdot i + z \cdot j$$

$$i = c.y/c.x, j = c.z/c.x$$

where x refers to the number of full-time major students in an academic year, y refers to the number of minor students in an academic year, z refers to the number of dual-degree student, i refers to percentage of minor courses credits, j refers to percentage of dual-degree courses credits.

C. Courses [10]

Courses refer to the number of courses that are converted into 3 credits,

$$Courses = \sum course$$

$$course = c/3$$

IV. CASE STUDY

A. The Introduction of Case Analysis Objects

Beijing Normal University, Zhuhai is a general higher-education and full-time school jointly organized by Beijing Normal University and Zhuhai Municipal Government. It carries out education at the undergraduate level and belongs to the nature of private colleges. In addition to a small amount of government funding, the funds for running schools mainly come from student tuition. The School of Management funds set up a two-level mechanism of university and college: The university allocates funds for colleges at a certain ratio; Colleges investigate outlay budget annually and have a certain sovereignty over subjects setting of teaching spending. There are altogether 15 colleges and 58 majors in the university.

The author's college is School of Management. The School of Management has 5 majors, including Human Resources Management, Financial Management, Information Management and Information Systems, Public Utility Management, Labor and Social Security. And it has 4 departments. Public Utility Management and Labor and Social Security such two majors are combined into one department. Other majors become a department itself. The number of students at college is 1800. In conclusion, the introduction of case analysis objects are School of Management and its' 4 departments at Beijing Normal University, Zhuhai.

B. Collection and Consolidation of the Raw Data in Teaching Process

Collection time of original data is from 2011 to 2016 in teaching process (a total of five academic years). The content includes the numbers of major, double major, minor students in each of four departments, teaching task, curriculum design, class design, course selection of students, etc. Because of large numbers of data, much categories, wide sources, complicated structure, we need to filter and integrate the data, make data consolidate together according to different academic years, then sort it according to different departments in order to analyze. Specifically data sources mainly consist of exported by system and manually finishing.

1) Data automatically exported by the school teaching management system (data: course data, student data)

Information platform of Deans Office's core business is relatively perfect in the university, including educational management system, teaching management assistant system,

attendance system, network experimental teaching platform, etc. But performing daily work depends upon multiple systems. Each system were purchased or developed at different times. Systems are independent from each other. There isn't a high level of integration between data and business. Business collaboration among other related department hasn't come true. The raw data automatically exported by system is not only large but also disperse.

The course data exported by system include all courses which are offered by School of Management, including compulsory courses, minor course, and general-knowledge courses. Major fields include: course name, course nature, credit, teacher name, students' number of course selection, and so on. These data mainly come from educational management system and teaching management assistant system.

TABLE I. STUDENT DATA SITUATION TABLE OF DEPARTMENT OF FINANCIAL MANAGEMENT (FROM 2011 GRADE TO 2013 GRADE)

Grade	Class	Student number	Academic Year				
			2015-2016	2014-2015	2013-2014	2012-2013	2011-2012
2011	major 1	55.0000	-	55.0000	55.0000	55.0000	55.0000
2012	major 1	57.0000	57.0000	57.0000	57.0000	57.0000	-
	double major	72.0000	24.7500	24.7500	24.7500	-	-
	minor	43.0000	8.0625	8.0625	8.0625	-	-
2013	major 1	54.0000	54.0000	54.0000	54.0000	-	-
	double major	37.5000	12.8906	12.8906	-	-	-
	minor	37.5000	7.0313	7.0313	-	-	-

TABLE II. TEACHING COST INDEX TABLE OF DEPARTMENT OF FINANCIAL MANAGEMENT (FROM THE 2011-2012 ACADEMIC YEAR TO THE 2015-2016 ACADEMIC YEAR)

Year	FTE	FCE	Courses	FTE/Courses	FCE/Courses
2011-2012	186.0000	519.1667	17.3333	10.7308	29.9519
2012-2013	350.0000	1430.6667	50.3333	6.9536	28.4238
2013-2014	535.8125	2444.5000	104.0000	5.1520	23.5048
2014-2015	723.7344	2628.3333	154.6667	4.6793	16.9935
2015-2016	704.2188	2607.3333	167.3333	4.2085	15.5817

As shown in Table I, Student data mainly come from attendance system and its statistics classified according to the grade, class, student number, academic year. Besides, classes include major, minor and double major. Because there is a small amount of students drop out of minor. And some students just drop out of courses. It's difficult for us to get the exact number of students. Besides, some students choose to attend classes with younger grades because of personal reasons. Author simplifies the numbers of minor and double major. When the numbers of minor and double major roll into one, each of them estimates base 50 percent. What's more, there are some students go to other schools study every year, the number of students has little change. But above students is low, it cause not big consequences. So it can be ignored.

2) College-teaching-affair secretaries manually finishing (teacher data)

Teaching-affair secretaries artificially add up and mark which department the teachers belong to, and then divide the

courses which the teachers teach into different department offers according to which department the teachers belong to, finally sort the data according to departments. Aim at special cases of teacher data, the method of data handling as follows: 1) When can not judge which department the teachers belong to, according to the nature of courses the teachers teach. Still be unable to determine, according to which department students being taught; 2) College counselors are lumped together into Human Resources Management Department, because the courses that these teachers teach mainly include innovative entrepreneurship and career planning, these courses are most relevant to Human Resources Management Department; 3) When encounters such situation that the same department's students are taught by two different departments' teachers in one course, the course is divided into two units, each one accounts for half of the credits. Two units separately fall into different teachers' department.

C. The Calculation of Teaching Cost Analysis Index

1) The calculation of FCE and courses

At the time of calculating FCE, calculate the FCE' first, then sum the FCE' of courses which established by departments, get the FCE (as shown in Table II). Courses are given in the same way. For example, the number of people taking course which named Management Accounting and established by Financial Management Department is 47 during the 2015-2016 academic year. The course divided into 2 credits. We can find out the Course FCE' = $47 * 2/6 = 15.6667$, course = $2/3 = 0.6667$. Then according to this method, calculate other courses established by Financial Management Department, after get FCE' and course of each course, respectively sum the FCE' and course, get FCE and courses of Financial Management Department in this academic year.

2) The calculation of FTE

At the time of calculating FTE, the number of students who minor or double major is calculated according to credits proportion. For example, the number of students double majoring in Financial Management Department is 72 during the 2015-2016 academic year. Credits of double major students need to get is 55. Total credits of major students need to get is 55. So $FTE' = 72 * 55/160 = 24.75$. Sum FTE of Financial Management Department, get FTE of Financial Management Department in this academic year.

D. Teaching Cost Problem Detection and Improvement

1) Teaching cost overall situation

The author through big data visualization of the various majors to show the changes from 2011 to 2015, and strive to make an intuitive detection of teaching costs. The vertical axis is FTE/Courses, the horizontal axis is FCE/Courses, and diameter is Courses. FTE is known as the number of school departments equivalent students, the majority of school departments students determine the number of school departments income, so here FTE can be seen as department of income; Courses is known as the number of courses offered by departments, the more courses, the more the cost of teachers required, so Courses can be seen as the school departments teaching cost. To sum up, FTE/Courses is the core indicators of the teaching cost of school departments. FCE is known to realize the transformation between enrollments and credits, and FCE/Courses is the number of elective students/the number of courses to get the number of elective students in one course. So FCE/Courses is the core indicators of the quality of teaching, as shown in Fig. 1.

From 2011 to 2015, the small balls represent the school departments from the upper right corner gradually move to the lower left corner, small balls diameters are gradually increasing. The vertical axis FTE/Courses is the departments of planning course scale, specific for full time equivalent/courses. The higher the FTE/Courses value is, the lower the teaching cost pressure of the corresponding departments this year; the horizontal axis FCE/Courses is the departments of actual course size, specific for full-course equivalent/courses. FCE/Courses value is greater, which indicates that the average number of actual elective courses

students is more, then the corresponding department service of this year is stronger, and the lower the professional quality, teaching quality will be relatively lower. So when the small ball in the upper right corner, indicating that the department is the service-oriented department, most of the courses for large classes; when the small ball in the lower left corner, indicating that the department is professional department, most of the courses for small classes. Analysis shows that the college in the development of nearly five years by the service type gradually transformed into a professional type. With the increase in the ball, representing the opening courses by department increased, with the increase in teaching resources, the strength of teachers, the college of courses in the rich, teaching costs are also increasing. Human Resources Management (HRM) Department in which to expand enrollment in the 2012 school year, so that the small ball greatly turns to the right, resulting in decreased quality of teaching, thus controls the enrollment in the 2013 year to return to normal expectations track, as shown in Fig. 1.

In 2015, the balls are concentrated in the lower left corner. This shows that the school departments' courses tend to be professional teaching, it can improve the quality of teaching, but also increases the pressure of teaching cost, is not conducive to the long-term development of the college, as shown in Fig. 1.

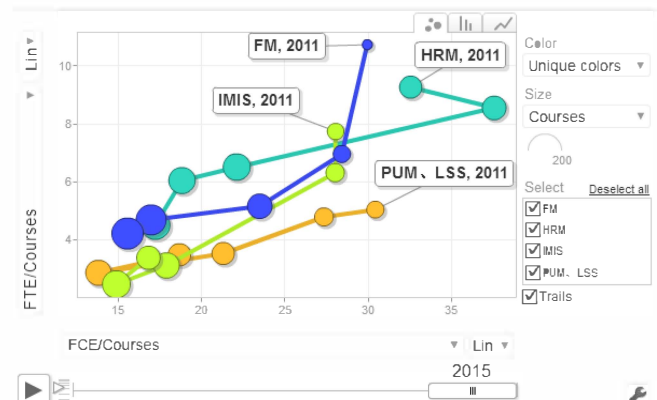


Figure 1. The Teaching cost analysis index process dynamic graph from 2011 to 2015.

2) Teaching cost problem factor decomposition

In order to find out the reasons for the improvement of teaching cost pressure, different possible factors must be decomposed. In connection with the existing theoretical materials, the author puts forward the innovative analysis of "external teachers" and "practical courses". "external teachers" means a teacher who has not been established in the college; "practical courses" refers to the students' comprehensive learning activities carried out independently under the guidance of teachers, is based on the experience of students, closely relates to their own lives and social reality, reflecting the comprehensive application of knowledge of practical courses. Specifically, colleges and faculties are in fierce competition now. In order to produce "benefit" as soon as possible, colleges and faculties will be used for the blind introduction of external high-level talents, lacking a stable

team of teachers. The easily lead to the practice of academic ladder team personnel structure imbalance, is not conducive to the sustainable development of and the steady development of colleges and universities. So the author make the "external teachers" as a possible factor to analyze. Furthermore, in the early stage of data analysis, the author finds that the number of practical courses' students is relatively small, the credits are heavier, occupying more teachers' resources. Therefore, the "practical courses" is also analyzed as a possible factor.

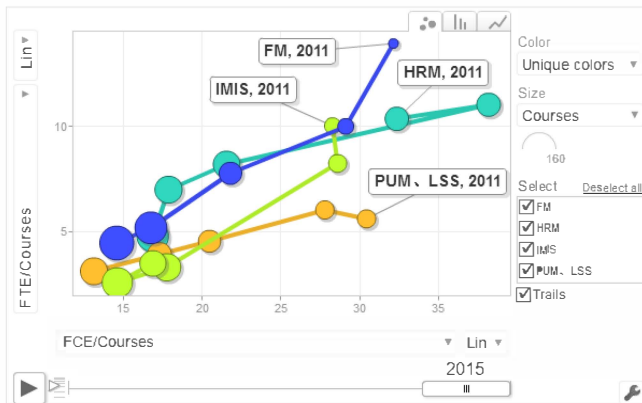


Figure 2. "External teachers" factor decomposition.

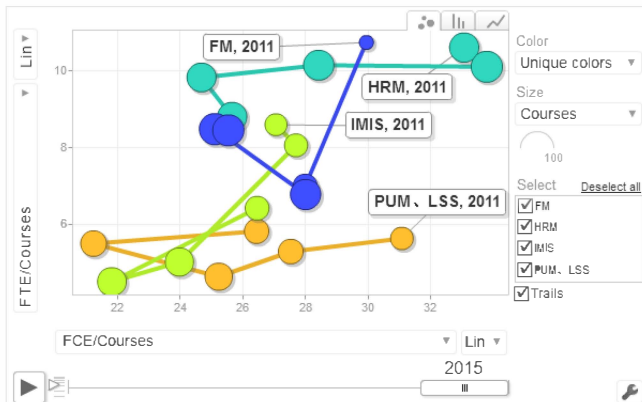


Figure 3. "Practical courses" factor decomposition dynamic graph.

From Fig. 2 and Fig. 1 show that the teaching cost analysis index in the presence of external teachers' trajectories are roughly the same, slightly different mainly in 2011 to 2013. Human Resources Management Department and Financial Management (FM) Department change a lot, indicating that this period of external teachers' factors on the two departments of teaching cost pressures rise have a certain effect. And the difference in the data between departments in 2015 is not obvious, indicating that the factor of external teachers' influence on the increase of teaching cost pressure is not significant.

From Fig. 3 and Fig. 1 show that after removing the part of practical courses, FTE/Courses and FCE/Courses index compared with before decomposition are increased, and in contrast to all courses, departments of the trajectories have great changes, which indicates that some practical courses

have an important influence on the teaching cost pressures. Especially for the Human Resources Management Department, the trajectory of Fig. 1 in 2014 is to the lower left, and Fig. 3 track is to the lower right. It shows that the courses of Human Resources Management Department is reduced, the class size of the course is larger and larger, and the corresponding teaching quality may become lower.

In addition, analyze and compare the trajectories without part of practical courses and all courses in 2015. Obviously representation of the departments of the balls gradually move to the middle part of the figure. Among them, represents the Human Resources Management Departments and Financial Management Department ball locate above the partial chart partial figure. This means that in the case of FTE is unchanged, that is, income remains the same, after the removal of some practical courses, the cost reduction. The other two departments tend to figure below, which shows that in 2015 the two departments to remove some of the practical courses, the teaching cost is still higher. The two departments of the corresponding balls positions are different obviously, which indicates that the practical courses factor is an important factor affecting the teaching cost rising.

3) Teaching management strategy improvement

According to the above analysis, the practical courses factor has led to smoothing the characteristics of the teaching cost analysis index of the other theoretical courses of school departments in School of Management. And data characteristics of Human Resources Management Department and Financial Management Department are similar, while the other two departments of data characteristics are very similar. So the college developed different teaching management strategy improvements.

Information Management and Information Systems (IMIS), Public Utility Management (PUM) and Labor and Social Security (LSS) should be appropriate to add courses, rational planning size of courses, expand enrollment. The results of the analysis of 2015, the three major FTE/Courses value is smaller, we can see that their teaching cost pressure is more. And the size of the balls on behalf of the various departments contrast can be seen that the two department of opening courses less, so it should be appropriate to add public elective courses, and reasonable planning courses size. But considering the additional courses will result in a small FTE / Courses value, namely add courses will directly affect the income from appropriation in School of Management. Thus the two departments should not only add courses, reasonable planning courses size, should also expand the scale, minor double degree enrollment to increase school departments' income.

Human Resources Management Department and Financial Management Department should be rational allocation of teaching resources, expand the teaching staffs. The results of the analysis of 2015, the two FTE/Courses value compared to the other two to be large, you need to take some measures to control FTE/Courses value. As a result, these two departments themselves open more courses. Further investigation revealed that it is known that there is a situation where a teacher teaches multiple courses at the same time, and although there is a higher income from

appropriation, it will have an impact on the quality of teaching. So for these two departments, the future should be in accordance with the school development and social needs, making reasonable enrollment targets, making reasonable planning of the courses and introduce into quality teachers rationally to improve the quality of teaching, and should not blindly add courses.

In addition, the practical courses is an important part of undergraduate courses, also it is an important factor that affects the rising of teaching cost. It is developing trend to strengthen the teaching practicality of undergraduate courses. The practical courses' teaching objectives require us not to blindly reduce the number and content of practical courses because of cost factors, but to find the balance point of teaching cost and income, and to guarantee the teaching quality of practical courses at the same time. Therefore, the college will further optimize the syllabus and teaching standards of practical courses such as “*Graduation Thesis and Design*”, “*Professional Practice*”, “*Mentor Workshop*”, “*Professional Quality Cultivation*” and so on. And gradually establish including peers, students and teaching supervision of multi-level teaching evaluation system to improve school benefit in the premise of rising teaching cost.

As a result of the practical courses with small classes teaching have caused the School of Management teaching resources waste, this research puts forward the following suggestions for the reform practical courses: first, set reasonable standards of student numbers; second, the practical courses will be opened as professional elective courses or individual courses, and not to mention the students are not interested in elective courses; third, strengthen the teaching quality assessment, encourage students to participate in academic projects, publish papers, and pay attention to the self-development of students.

V. SUMMARY

The article regards the teaching-cost problem of private colleges as hole, and shows informationized quantitative analysis method based on teaching management decision support of big data which can make teaching management decision more rational, accurate and forward looking. During the practice, the main difficulty is that collection and consolidation of the raw data in teaching process, including conformity issues of heterogeneous system data. These is directly related to the informatization level of teaching and management in university. What's more, standardization level of university teaching and management also is one of keys to the big data's applications in the education industry. So under the background of big data in the education realm, which university's informatization construction basis of

teaching and management is good, and management is normative will get ahead.

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